**The Prince of the Heart**

 It was an unbelievable moment. As spectators looked on, a man gutted a Barbary macaque in the middle of a city plaza.  There, before the crowd, he challenged anyone to put it back together. The moment was madness, but the man was not mad. He was, almost inarguably, the most important medical scientist in history. His name was Galen, and this moment before the crowd was his coming-out as a performer and as a scientist.

Galen, or Galenus of Pergamum, was born in AD 129 in Pergamum, near the Aegean coast of what is now Turkey. He was, at least by his own reports, a kind son and a dutiful student. Upon finishing school, and at the suggestion of his father, he traveled to Alexandria, the great city of learning. Galen's father had seen in a dream that his son would be a great doctor. Galen would later speak often of this dream, emboldened by his father's premonition to strive even more eagerly. Following his training and his father's death, Galen looked to establish himself. He needed a livelihood. After the sort of wayward traveling that even today makes parents nervous, at the age of twenty-eight, he decided that he would like to begin his career as a medic to gladiators, once again in his hometown of Pergamum. There was a problem, though. He needed to be chosen from among many candidates. This was too important an opportunity to leave to chance.

 The potential gladiatorial doctors were asked to meet in a public area. Galen is said to have brought with him a very hairy and ill-fated ape (actually a Barbary macaque). While the other doctors looked on, Galen eviscerated the macaque. This was his moment. It was madness; it was horrible. But Galen had his reasons. Standing above the animal, he challenged the men around him to put it back together again. No one but Galen could. He got the job (or, in some retellings, at least secured the job that was already his). Galen might have been trying to say that in order to tend to gladiators, you needed to be able to put their guts back together. But the message the other doctors probably heard was something more like *I'm so crazy, I'll cut open a macaque; you don't want to try to take this job from me.* Either way, it worked. Galen had already acquired some of the brash skill that would bring him fame.

Galen took up his position with the gladiators. He traveled with them during the winter, spring, and fall training months and he worked  alongside them. He was a fight doctor, and his was a world of sweat and blood and well-trained men, men whose bodies and, particularly, hearts worked slightly differently than the norm. We know now that in an endurance athlete, the heart's left and right ventricles expand in order to pump larger volumes of blood to the body. The relaxation of the heart between beats also becomes more extreme.

 By contrast, in a strength athlete, such as a bodybuilder, the heart's ventricles do not necessarily get bigger, but they get stronger, and the heart relaxes less, rather than more. In the movies, gladiators look like bodybuilders. In reality, they probably looked more like chubby, small-town strongmen. They ate a special vegetarian diet of barley and fava beans to become somewhat fat, the idea being that the fat might help protect them from wounds. Yet, despite the fat, gladiators did exercise, and it seems likely that their bodies were the result of a mix of strength and endurance. One expects that their hearts were a mix, too - strong and big and never terribly relaxed.

 In the summer months, fights were staged, and Galen would wait for the injured. A coliseum rose above him, and in its stands Galen could hear twenty-five thousand fans cheering and booing. They loved the spectacle of the gladiators battling in the dry dirt. The fans felt as though they were fighting too. Galen heard them cursing. He heard them moving. He heard their bodies above him, around him, a great mass of hands and legs, flesh, and, buried in the bodies - hidden but so easily revealed - hearts, livers, kidneys, veins, and arteries, all of which he knew were there and yet could not explain. As he stood in the heat of a crowd, he dreamed of greatness, but not that of the gladiators. He dreamed of his own.

The gladiatorial battles alongside which Galen stood were the precursors of all sporting events that would follow – every one you have ever been to. It is not hard to see the fans of gladiator events in the faces and actions of soccer or football hooligans. And the gladiatorial arena would be the precursor to the stadium, but also to the surgical theater. To Galen, the gladiators were titillating as they ran at each other with their weapons raised. But more titillating was the subsequent struggle, his struggle, to save the men who had been wounded. Anyone could kill a man. Only Galen could so consistently bring a man fated for death back to life, at least according to him. He wanted and felt he deserved a crowd.

Galen's predecessor had lost many gladiators to injury. The wounds were too deep, infection too overwhelming. Gladiators died one after the other. But not on Galen's watch. In the entirety of his time tending to the gladiators, just five men died. Perhaps being able to stitch up a macaque actually was useful in stitching up gladiators, or perhaps Galen was ambitious enough to be both self-aggrandizing and great.

 As Galen sewed the bodies of gladiators back together, he made scientific discoveries. The bodies of the gladiators were specimens in that the muscles, nerves, and veins were, if not exactly obvious, then at least more obvious than in the average man. The gladiators could be learned from. Seventeen hundred years before Leonardo da Vinci would carefully sketch out the body's external details, Galen was gaining daily experience with its internal ones. The gladiators' wounds were, as Galen would write, "windows into the body." It was thrilling for him to look into wounds. Was it joy, a kind of love? Galen would later do experiments in which he would track the heartbeats of lovers when they were reunited (or pulled apart). Love made the heart pound, and Galen loved discovery; it made his own heart race beyond his control. Today we know that love, rage, and other strong emotions affect the amygdala, a  group of neurons in the most ancient part of the brain. The amygdala triggers the release of hormones that affect many organs,  including the heart; the hormones can cause the heart to speed up, which sends more oxygen to the brain. All Galen knew was that he  could feel this effect. He could feel his heart running as he saw the living, working parts of bodies, parts very few other people had ever seen.

In Galen's Roman Empire, most doctors would not have seen the heart even in a dead body. The Romans waffled on what was necessary in the afterlife and so prohibited all human dissections; better to be safe than sorry. The sliced-open bodies of the gladiators would have to suffice for Galen. Working on these bodies,  Galen sometimes paused longer than he should have, to look. He  may even have seen a beating heart. (He definitely saw one later in life, when asked to tend to a boy with a chest infection. Galen cut  into the boy's chest and saw his beating heart. He may even have cut into the boy's pericardium, two thousand years before the next such cut, by Daniel Hale Williams in Chicago.) Certainly, Galen saw the roads of arteries and veins. He saw enough to begin to sketch, first in his mind, then on a papyrus, a semblance of the intimate geography inside all of us. He was the first real geographer of  our untraveled reaches - Captain Cook of the high seas of blood - and though he would err in how some of the regions connected, mistake some peninsulas for islands and so forth, his would be the  map that would allow all of those who followed to proceed, to hesitantly check the boundaries he had so carefully limned.

As Galen continued in his role with the gladiators, he learned and profited, but the former more than the latter. He wanted more - more money, fame, and understanding. Eventually, Galen retired from his gladiator job and began to work as a sort of traveling doctor and showman. Doctors already existed, but their treatments had very little to do with actual diagnoses; Galen was, arguably, the first doctor who aimed to understand what caused ailments and then to treat those causes based on the results of testing the treatments on multiple patients. He had learned about science from Alexandria. Now he was learning to treat illnesses (not just mending wounds, which was his focus with the gladiators) by empirical trial and error. His doctoring allowed him to see more kinds of afflictions. His performances, at which he would dissect an animal, treat a patient in public, or otherwise make a spectacle, allowed him to both garner support and, however informally, teach. His research, which often occurred during public dissections and displays of doctoring ability, allowed him, each time he looked, to understand more. It was the performance and the research that motivated him; he wanted to understand and then be able to display that understanding to the masses.

During these years (and, for that matter, in the fourteen hundred years to follow), Galen had no rivals. Across the entirety of the Roman Empire, stretching from modern Scotland to Egypt, Galen's accomplishments were lauded. He became a legend in his own life, so much so that at the margins of the empire, the story of his life became exaggerated, imbuing him with the status of a sort of half-god. His reputation traveled by word of mouth - in response to his performances, for example - but also via his writings. Galen wrote volume after volume about both what he had discovered himself and what was already known but not well consolidated. These volumes were greedily consumed throughout  the Roman Empire and beyond. Thanks to this fame and success,  Galen eventually became the physician to the emperors. He tended to their royal bodies with tender effectiveness, just as he had once tended those of the gladiators, but the pay was much better. He also continued to write. Or maybe it is better to say he continued to speak. He wrote his books by talking. A dozen very busy scribes recorded his every word, words that eventually came to comment, in great and lasting detail, upon the biology of the heart.

 When Galen recorded what he knew about the heart, he built on  millennia of observations, some of them formal, others part of the sort of everyday understanding of the organ every hunter must have seen beat when he dissected the freshly killed body of his prey. All around the world, hearts had been seen. After an elephant was killed, its ponderous heart was thrown to the ground, a giant house of muscle to be entered through the blood vessels' wide caves. The tiny hearts of birds were dried and worn like decoration on strings.  Native Alaskans stood beside whale hearts and felt small. One ten-thousand-year-old cave painting in Pindal, near Altamira in Spain, shows a bright red heart inside the body of a mammoth. The hearts of animals were varied and yet recognizable as hearts. They beat the way human hearts would ultimately be seen - in war and accidents - to beat. Even before we knew what the heart did, we knew that it was the measure of a life, be it in a bird, a squirrel, or one's kin. It sped up in fear, eagerness, or bravery, and when it stopped, the creature that housed it would die. The heart was and is the most deadly place to be stabbed, the most vulnerable clump of  muscle, only marginally protected beneath the shallow cage of the  ribs. The modern wounds from knife fights are still very often in the heart. Whatever it was, in whatever body it might be found, the heart was simultaneously weak and powerful.

Just how the powers of the heart were understood varied from place to place. Yet those stories of the heart we know the most about, despite being separated by oceans and time, share many similarities. To the Aztecs, for example, the heart was infused with the sun's borrowed fire, but that fire had to be returned. To return a bit of fire to the sun, the Aztecs cut the beating hearts of sacrifice victims out of their bodies. The priests who did this cutting (and, as if it weren't already brutal enough, tearing) would have seen more living hearts than anyone else up to that point in history. They would have known the weight of a heart and many of its specific details. They gathered enormous clay jars full of human hearts that would, at the end of the season, be poured into water, whether ocean or sea, in gratitude for the sun-blessed crops. In the intervening months, the hearts would be placed where they could be observed and contemplated. The result of that contemplation was not recorded; the Aztecs left no comment about what they thought the heart did or why - only that they, like nearly every other culture, regarded it as important. The Aztecs decided to remove hearts, not livers, kidneys, or stomachs,  from those who were sacrificed. Continents away, the Egyptians left the hearts alone in the bodies of mummies to be transported into the afterlife, when  the heart's fire remained necessary. Later, in Greece, Plato also linked the heart and flames. He wrote, "The swelling of the heart which makes it throb with suspense or anger was due to fire."

In most cases, the specialness of the heart extended beyond mere biology. Across cultures, the heart is the most frequent seat of the soul, the spirit, or the breath of God or the gods. Among Christians, Jesus was said to live inside the chambers of the heart. In ancient Egypt, the heart was the home of both the soul and, by some reckonings, consciousness. There are exceptions, of course; one Australian tribe believed the soul to live in the fat around the  kidneys, and the Mesopotamians found their souls in their livers, but these cases stand out for their very unusualness.

 Explanation of just what the human heart was awaited the origin of scientific societies. Long before Galen, the first detailed account of the heart's biology is found in the Ebers Papyrus, an Egyptian medical encyclopedia recorded on a sixty-foot-long scroll written by the  scholar Imhotep in roughly 2600 BC. The oldest remaining copy is a relatively recent one from 1700 BC. If one takes the time to carefully unroll and read it, several ancient stories of the heart are revealed. One can be found in a section entitled "The Beginning of the Physician's Secret: Knowledge of the Heart's Movement and Knowledge of the Heart." There, Imhotep wrote that there are vessels "to [the heart] from every limb.... When any physician ... applies the hands or fingers to the head, to the back of the head, to the hands, to the place of the stomach, to the arms or to the feet, then he examines the heart, because all his limbs possess its vessels, that is: it speaks out of the vessels of every limb." In the Ebers Papyrus, the heart is considered to include the vessels leading to and away from it; the heart is the whole cardiovascular system, the muscle itself but also the rivers coursing from head to toe and, though it was not yet known, back to the heart.

The heart spoke to the Egyptians in terms of both its physical form and its metaphysical possibilities. Yet the Egyptians, for all their knowledge, seem to have understood very little about what the heart had to say. Its movement conveyed meaning that could be felt anywhere in the body. It beat out a story, but what was the heart carrying on about? The Egyptians could not yet offer a compelling translation of the heart's rivers and backwaters, their murmuring synonymous with being alive.

 Finally, in Alexandria, Egypt, twenty-three hundred years after Imhotep, the science of the body began to advance anew, as did nearly all other intellectual endeavors. In 330 BC, Alexander the Great had founded Alexandria. It was to be an ideal city, ruled by Ptolemy I. In Alexandria, life on earth mattered and affluence abounded, so philosopher-scientists had both the mandate and the funds to begin to explore the material world - and that included the body. The science of Alexandria began in a new and grand museum called, simply, the Museum, or the Alexandrian Museum, a sort of university dedicated to the intellectual muses. Down the street, the Library at Alexandria stored as complete a record of the history of the world as had ever existed.

Walking through Alexandria, one could bump into Euclid absent-mindedly pondering his new math or Eratosthenes trying to measure the diameter of Earth (and coming within fifty miles of getting it exactly right). Then there was Hipparchus cataloging the stars. Hero was at work designing a steam engine. Archimedes came to visit and learn.

The anatomists of Alexandria worked in the museum and read in the library, but their place of real discovery was the medical school. In that school, the earliest of its kind, dissections and vivisections were permitted for the first time in thousands of years or maybe, at least for scientific ends, ever. Criminals were examined while still alive. Some of what we know about our own bodies today is thanks to their horrible fates. Their vivisection allowed philosophers clear views of living human bodies, clearer than would be seen again for two thousand years. Philosophers could hypothesize as to what the body did and then test those ideas, one life at a time.

 As they looked into bodies, the philosopher-anatomists of Alexandria built on the ancient knowledge of Imhotep. They had also  benefited from recent discoveries. In roughly 500 BC, Alcmaeon of Croton noticed that when he was looking at dissections of animals, the arteries and veins (though he didn't know what they did at the time) seemed "different" from each other, though precisely how or why was beyond what he was prepared to say. Presumably others had noticed these differences too, but Alcmaeon recorded what he saw and got the credit. Aristotle (384-322 BC), adviser to Alexander the Great, built upon Alcmaeon's observations and made a few new ones. Aristotle looked carefully enough at the heart to name its parts. He thought he saw in the heart three chambers, the left ventricle and atrium and the right "chamber," which we now regard as being composed of two parts, the right ventricle and right atrium. Aris-totle reaffirmed too the importance of the heart, bestowing it with the soul (as others had), but also with thought itself. To Aristotle, the brain was filled with nothing more than mucus; the heart,  however, was a thinking man's organ. Today we describe ourselves as thinking with our brains, and it is hard to imagine any other repository of our thought, and yet for much of history, the location of the human mind drifted in the body, subject to new theories.

 In Alexandria, Herophilus (335-280 BC) built upon this knowledge and was the first to notice that one type of vessel (what we  know today as arteries) was thicker than the other (veins), and muscular. For that he was lauded. Even in Alexandria, progress was  painfully slow when measured against the extent of the ignorance of the time; the ancient boats of discovery were still bumping clumsily along the body's uncharted shores. Herophilus (who is sometimes called Chalcedon in reference to his place of birth) also made another discovery. He thought that he had discovered that both arteries and veins contained blood. Until then, the arteries and  veins, as well as the heart itself, were thought to be filled with air (the word *artery* is even from the Latin word meaning "air ducts").  This misconception arose because in death, without the pressure of a beating heart, blood quickly drains out of the body's arteries (and, to a lesser extent, veins). In the dead, the arteries are air ducts, the heart itself a vessel. So persistent was the idea that the heart was filled with air that Herophilus's friends and his clever colleagues thought he was wrong. Erasistratus (304-250 BC), Herophilus's slightly more youthful contemporary, was among those who insisted that air alone inhabited the heart's muscle, as well as the arteries and veins. (Erasistratus was no dummy; he was the first of the body's explorers to correctly suggest that the heart was a sort of pump.) Herophilus and Erasistratus agreed on one thing: whatever the substance traveling from the heart out through the blood vessels, it invigorated the body with life. It was on the basis of the knowledge of these men that Galen began to build his empire of observations, a kingdom of facts that would stand the test of centuries.

 Galen probably knew the history of his intellectual forebears better than we do today, since the great Library of Alexandria burned down in the years after Galen, and we are left with just footnotes of the knowledge that had accumulated by Galen's time. Galen himself went to Alexandria for some of his training. Then and afterward, he was especially interested in the heart and what we now call the cardiovascular system. Galen thought of this system as being mechanical (he seemed to have already banished both the gods and the soul from the body, to his own satisfaction), and in order to test the makings of its mechanism, he needed and wanted to do experiments. But he had a problem: Now that he was no longer mending gladiators, he was rarely able to see inside human bodies. Vivisections had become a thing of the past. They were off-limits to him, as were dissections of humans in general. He could not even do simple experiments on humans, experiments of the sort now permitted - albeit only after approvals are obtained - in Western  medicine. He wondered what would happen if you clipped a vein shut. Would the blood pool above it or below it? No one had ever thought to ask the question before. In the absence of human subjects, how could he find out?

 Galen's progress came to rely on the law of similarity, namely, that the bodies of different animals are sufficiently similar to one another that if you study one, it will tell you (imperfectly and yet still usefully) about others. Two thousand years before Darwin, Galen recognized and relied upon the kinship of humans to other animals, and we still rely upon it. When new products or treatments need to be tested, they are first tried out on guinea pigs, rats, dogs, cats, or monkeys. They are tested on those animals because the animals are similar enough to us to be useful measures of how our own bodies operate. Then, if everything works in the nonhuman animals, the same products and treatments are tested on humans (college students, fairly often). As Galen put it, "The bodies of different animals are the same so you can study one animal and learn about the other; you can study dogs and learn about humans." Researchers do animal testing because Galen popularized the approach; his legacy lives on in the millions of rats, mice, and guinea pigs used in labs as proxies of human bodies.

Galen did not believe absolutely in the law of similarity. He knew that dogs and macaques were not humans. He knew that similar bodies did not mean identical bodies (this would later be forgotten by his disciples), and yet he thought that if he dissected and experimented on dogs, he might begin to understand the human body. While human dissections were prohibited in ancient Rome, those of other animals were not. Galen could dissect as many dogs as he wanted, so he did. He also dissected pigs, goats, sheep, horses, asses, mules, cows, lynxes, stags, bears, weasels, mice, snakes, fish, birds, and an elephant - along with whatever else he could catch or import.

Galen confirmed that the heart was filled with blood and that the veins and arteries were different from each other, and he observed for the first time that the blood in the veins and arteries was also different. The blood in the arteries was red; that in the veins was purple. One dissection at a time, he was beginning to make the observations on which a modern understanding of the heart and cardiovascular system could be built.

Galen, having mapped the heart's general features, decided the next task was to understand the heart's function. From Galen's classical perspective, each organ had a function and a kind of internal autonomy. He believed that many organs produced vital substances; this was his modest retooling of a more ancient cosmology of the body handed down to him from the early philosopher Hippocrates (born around 460 BC) and his disciples in the form of a series of books called the Hippocratic Corpus. The lungs produced phlegm, the gallbladder bile, the spleen melancholic black bile, and the liver blood. For a human to be healthy, these substances needed to be balanced. In the writings of Hippocrates, the heart, though, was different; it pulled substances to it, and it was possessed of a gravity of the kind that would much later be attributed to the sun. The heart, in essence, demanded from the other organs, and they obliged. In light of these perceived functions, Galen began to craft a more detailed vision of what he thought the cardiovascular system did.

 Galen was burdened by the old ideas about organs as he looked at bodies; they colored what he saw. Through the cultural lens of ancient science he came to believe veins originated in the liver. There, he theorized, digested food from the stomach mixed into thick purple blood and traveled through the veins to the rest of the body, where the blood was depleted by the body's demands before traveling to the heart. Once in the heart, the blood traveled two places. Some of it (the vital blood) traveled to the lungs, he (rightly) imagined. But much of the blood traveled directly from the right to the left ventricle, through  tiny pores, he thought (incorrectly). The blood from the lungs, he believed (again rightly), traveled back to the left side of the heart, from whence it would distribute the "spirit" it had gathered in the lungs to the body via the arteries. Galen somehow also understood that in some parts of the body, the arteries and veins met.

 In the most charitable reading of Galen's understanding of the heart, one could say he essentially discovered the circulation of the blood. He was wrong about the role of the liver (although only partially; the sugar in the blood is released from the liver, so part of what's in the blood does come from the liver). He was wrong, too, about the holes in the heart through which blood flows right to left. But even this error is far from absolute. If we conjecture that some of  the bodies that Galen was studying were fetuses, his ideas are even more right than they seem to be. In a mammalian fetus, blood actually passes directly through a hole, called the foramen ovale, that's between the right and left atria (not the ventricles). This hole seals up during development, but it is open for a while. The main problems in Galen's model were his insistence on the ancient belief that blood was produced in the liver and consumed by organs and, of course, his theory of what blood was and did. But he was getting close.

Had Galen been able to conduct vivisections, I suspect he would have figured it out. He was clever, but his cleverness was constrained by the tools and concepts at hand. He was like a geologist who has to infer the history of Earth from the evidence of past events - tectonics and sedimentation. It is possible, but difficult. Even the geologists have advantages over Galen. They can look at a volcano and imagine a historic volcano. They can feel an earthquake and imagine ancient earthquakes. They can watch the settling of sediment on the river bottom and imagine millennia of sediment. Galen could not do anything similar. He could not watch the beating heart or even a pump that might inspire his reasoning. Science often proceeds by analogy or metaphor, and there was no physical device yet constructed that worked like a heart.

It has become popular to look on Galen as having gotten things wrong. He did get some things wrong, but every scientist does; our mark is not where we err but instead where we improve upon previous errors. Galen made far more advances than retreats, and even those who criticize Galen for what he missed live in his influence. Galen's discoveries are everywhere. He was the first Western scholar to take the pulse of patients and use it as a measure of their health. He was the first to urge other doctors to cool down patients with fevers and, conversely, warm up patients with chills (or colds). The idea that physically weak people could be made stronger through exercise came from Galen. Then there were true innovations so radical they would not be practiced again for nearly two thousand years. Galen used a needle to remove cataracts; similar surgeries would not be done again for another eighteen hundred  years. He appears to have even conducted brain surgeries in which he removed tumors through holes drilled in the skull, the precursor to modern versions of tumor excisions. Galen has a strong grip on modern life, just as Roman cities and architecture have a strong grip on modern cities and their design. Galen knew that he didn't comprehend everything, so he kept exploring, trying to understand the body. The quest to probe the body a little more each generation to reveal new truths is his legacy too.

 Unfortunately, Rome began its decline just after Galen's death and descended fully into chaos in its Western realms with the death of Romulus Augustus around AD 476. The fire of learning that had been passed, culture to culture, to the Romans from the earlier Greeks, to whom it had been passed by the Egyptians, to whom it had been passed by the Mesopotamians, was extinguished. The light went out. The colonizing hordes were interested only in their gods or their own satisfaction, depending on the horde under discussion. The papyrus scrolls in the library in Alexandria (including the original Ebers Papyrus) were burned, and with them, the quest to  understand the human body turned to ash, demons, and deities.

 So began a time that used to be called the Dark Ages, a time during which religion would be valued over all else. Terrible things would happen. Small states would come to war, feudally, against each other. Writing itself disappeared in some places. The medical texts of the Greeks and Romans that survived the fires were neglected.  Had all of this happened over the course of one generation, someone  might have remembered the old ways. But it was not one generation; the ignorance persisted for hundreds of years, during which knowledge continued to be lost until the point when all of Europe seemed to be inhabited by men and women who knew no more about their own bodies than had hunter -gatherers at the dawn of humanity.  They lived in a world of spirits and ignorance where the heart, once again, beat not with blood but with magic. They looked up at the bright moon and saw God. They looked at the sun and saw God. They looked at each animal and plant and saw God, and when they looked at people dying, they figured they saw God too, working the  strings of their bodies, snapping what could be snapped, pulling what could be pulled, all beyond explanation or need for corporeal concern. A dark fatalism killed nearly all that had been learned.

 Perhaps this is too harsh a depiction. Among historians, it has become unpopular to describe the period after the fall of Rome to around the year AD 1000 as the Dark Ages. Historians will point out that here and there, pockets of learning continued. Documents were preserved and cherished. Individual small flames were passed, hand to hand, generation to generation - treasured bits of knowledge. This, of course, is what one hopes: that despite all that was being lost on the large scale of Europe, there were individuals who still cherished knowledge. How could there not be someone who wanted to know more? Yet, when it comes to the heart, the opaqueness of the Dark Ages was nearly complete. In the years between AD 400 and 1400, little new understanding was gained about the workings of the heart, arteries, veins, and blood. Knowledge during this time deteriorated rather than improved. Realistically, less was known about the heart from AD 1000 to 1400 than was known in AD 400; less was known then, for that matter, than was known at the end of Galen's career, two hundred years after the birth of Christ.

 Initially, Galen's work seemed to have been lost to science altogether. In Western Europe, not a single copy of one of his scrolls seems to have survived. But in the eastern part of the Roman Empire, his writings had, it would turn out, continued to be copied and translated, from Latin to Arabic and then from one Arabic copy to the next. Muslim scientists prevented ancient knowledge from being lost in its entirety, not just that of Galen but also more generally. Not all of Galen's millions of words were translated, and meaning and context could be lost in translation, but his flame was passed. When scholars in Western Europe, particularly in Italy, rediscovered these translations, they cherished them - too much in fact. Galen's words seemed so advanced, relative to the knowledge of the time in Europe, that they were treated as literal scripture, wisdom handed down from an authority, to be revealed, not built upon. The sciences of anatomy and human biology came to circle Galen, Galen the great, Galen the perfect, Galen the prince.